WINDROWING AND RIPPING—A COMPARATIVE STUDY WITH OTHER SITE PREPARATION TECHNIQUES

D. W. GUILD*

SYNOPSIS

Frequent droughts and poor, stony soils are severe establishment hazards in Balmoral Forest. Site amelioration by windrowing and ripping prior to planting was introduced in 1966. Preliminary investigations have shown that the new crops are already benefiting from greatly improved survivals, better height growth and more uniformity than before. The cost of establishment has been reduced and the effect of ripping on tree growth, crop uniformity and stand access is expected to increase the initial cost advantage. It will not be known for some time whether or not the stands are more windfirm on ripped soils. Further trials and consequent improvements are expected to reduce the inefficiencies and increase the versatility of the technique.

INTRODUCTION

From the economic point of view radiata pine *(Pinus radiata)* is the best choice of exotic species for Balmoral Forest. Although there are some 12,000 acres of this species growing in Balmoral, establishment has not been easy and has led to the planting of large areas of slower growing and less marketable Corsican pine *(P. nigra)* and ponderosa pine *(P. ponderosa)* on the harsher sites. The recent introduction of windrowing and ripping prior to restocking has dramatically reduced the establishment problems of the more lucrative radiata pine.

Both windrowing and ripping involve the use of crawler tractors of 250 h.p. or more. Stumps and debris left after logging are consolidated into long parallel heaps at regular spacing leaving the ground clear for ripping (Wilson, 1969) in lines parallel to the windrows and at a spacing corresponding to that required between rows of trees at the time of planting. Ripping may proceed without windrowing in new areas devoid of obstructions.

It is the purpose of this article to outline the establishment problems in Balmoral Forest and compare establishment success using previous techniques with windrowing and ripping.

ESTABLISHMENT PROBLEMS

Both geology and climate of the Culverden Plain are factors which contribute to the establishment problem in Balmoral Forest. The natural vegetation reflects the rigorous nature of the growing conditions. Scrub manuka *(Leptospermum scoparium)* and *Cassinia fulvida* are dominant amongst native

*Forester, N.Z. Forest Service, Balmoral Forest.

tussocks and a scattering of introduced weeds such as broom *(Cytisus scoparius)*, gorse *(Ulex europaeus)*, nassella tussock and grasses. None presents an establishment problem.

The Plain consists of compacted greywacke boulders, gravels, sands and silts considerably mixed by fluviatile action and laid down during the Pleistocene. A series of narrow, shallow terraces bordering the Hurunui River to the south reflect a number of upward movements of the Plain in Recent times. All of the soil types recognized in the forest are of relatively low agricultural fertility. The shallowness of the soils and the compacted nature of the parent material effectively restrict tree rooting to less than 24 in. in depth. Tree growth appears to be greatly affected by the drainage capacity of the soils — the best growth being on a small, low terrace of freely drained Waimakariri soils.

The Plain is subjected to a low annual rainfall averaging 27 in. at the headquarters (650 ft a.s.l.) but increasing to 32 to 37 in. at the western end of the forest (900 ft a.s.l.). The dry bulb temperature extremes are 89.9° F for the January mean maximum and 17.4° F for the July mean minimum. Strong, warm winds from the north-west are often associated with very low humidities and these aggravate the growing conditions during not infrequent periods of summer drought. Although the nor'westers provide a constant threat of windthrow, winds from other quarters such as the south-west have been known to take their toll. In addition to windthrow, the climate is also responsible (in part, at least) for leading shoot dieback which is a common occurrence in most of the forest.

It seems reasonable to conclude that it is a deficiency in soil moisture, rather than minerals, which poses an establishment problem and limits growth over most of the forest. This deficiency is a result of a combination of:

(1) Poor internal drainage capacity of most of the soils.

(2) Low annual rainfall.

(3) High rates of evaporation during periods of low humidity and high wind speed.

Added to this is the constant threat of windthrow resulting from restricted rooting and strong, gusty winds. These problems are shared with Eyrewell Forest, about 45 miles to the south, as reported by Wendelken (1966).

FACTORS LEADING TO THE ADOPTION OF WINDROWING AND RIPPING

Extremely poor survivals on the lowest terrace led to an early abandonment of establishment attempts on these Selwyn soils. Acceptable stocking rates were achieved on the higher terraces only after persistent blanking and often only after resorting to pit planting. The nature of the soil enforced the use of mattocks as planting tools and 1/0 planting stock was favoured in view of the short blades.

Natural regeneration was not readily forthcoming as a substitute. Two disasters — a heavy snowfall followed by severe windthrow in 1945, and a devastating fire in 1955 — proved that some degree of soil disturbance was necessary for the successful establishment of natural regeneration. Scarifiers used to till the soil lightly after the 1955 fire helped spread the seed shed as a result of the fire and effect a satisfactory level of re-establishment. Clearfelling of the first crop following the completion of salvage after the 1955 fire showed that unjustified faith had been set in the ability of radiata pine to regenerate naturally in logged areas. Observations in these areas showed that birds commonly consumed over 90% of the sound seed shed. Results were no better after trying felling coupes in the form of strips and wedges at various orientations both with and without seed trees. Furthermore, the depth of logging slash made all clearfelled areas inaccessible to planters for an average of six years after logging. Little natural regeneration occurred, and much of this was severely malformed while pushing up through the slash.

Pit and plough-furrow planting trials by Prior (1963), confirmed suspicions as to at least part of the cause of high failure rates of planted radiata pine stock. The trials were established. in 1954. Results were assessed in 1958, and are given in Table 1.

TABLE 1: SURVIVAL OF RADIATA PINE AFTER PLOUGHING AND PIT PLANTING

Treatment	*Survival* No. of Trees	%	*Control*	*Survival* No. of Trees	%
Furrowed ground:			Flat ground:		
(a) Unfenced	12	20	(a) Unfenced	1	2
(b) Fenced	28	67	(b) Fenced	6	14
Pit plantings:			Flat ground:		
Unfenced	17	34	Unfenced	78	17

This trial demonstrates the value of aerating the compacted soils prior to planting, and the damage that can be expected from rabbits. A replication of this trial on silty ground showed that the differences due to soil type were greater than those due to treatment. This, of course, reduces the significance of differences between treatments. Prior (1963) emphasized that the practice of pit planting is expensive and its use should be limited to small-scale plantings, while furrowing is restricted to areas free from stumps and slash.

In an attempt to beat the slash without destroying potential natural regeneration, supplementary planting was undertaken in areas that had been worked over by a slash rake or crushed by a heavy tractor. Table 2 bears out the poor results in these and other planted areas.

The survival figures for compartments 6 and 34 are deceiving in that the recruitment of natural regeneration was counted towards the survival of planted stock.

TABLE 2: SURVIVAL OF RADIATA PINE RELATED TO METHODS OF SITE PREPARATION OTHER THAN RIPPING

Compt.	*Site Preparation Technique*	*Year Est.*	*Age of Stock*	*Surv. 1st Year (%)*	*Age of Blanked Stock*	*Surv. 2nd Year (%)*
6	Slash crushing	1965	1/0	12	1½/0	68
34	Slash crushing	1966	1/0	39	1½/0	80
50	Burnt area	1962	1/0	68	1/0	75
55	Burnt area	1962	1/0	61	1/0	82
66	Unprepared	1966	1/0	56	2/0	70

The natural progression was to try some other mechanical means of ameliorating the site. Machine clearing trials, outlined in Appendix 7 of *FRI Symposium No. 11* (1969), revealed that ripping following the removal of debris by windrowing may have the desired effect. It was believed that ripping might help in the following ways:

(1) Enhancing survival by
  - (a) Loosening the soils sufficiently to allow free drainage and aeration.
  - (b) Providing channels to collect surface run-off from the unripped portions and thereby increase the amount of water available to the trees.
  - (c) Giving the tree roots free access to greater quantities of soil moisture.

(2) Allowing the development of a stronger, deeper root system resulting in a more windfirm stand.

Over the period of the trials, the specifications finally adopted were that the ripped lines should be 8 ft apart in order to comply with the required distance between planted lines. The lines were to be oriented across the path of the north-west winds so that the new crops would be somewhat sheltered by the parallel windrows. Ripped lines were to be 18 to 24 in. deep and this allowed the use of two standard rippers mounted 8 ft apart on the rear hydraulics of the tractor. The same tractor, fitted with a conventional blade, was to be used for windrowing. Windrows were to be formed every 3 chains in order to limit the size of individual windrows and provide an economic distance to push the debris. Windrowing, however, is necessary only to clear the ground of obstacles prior to ripping.

The first three trial areas, ripped and planted in 1966, gave the results presented in Table 3.

TABLE 3: RESULTS OF RIPPING TRIAL

Compt.	*Age of Stock*	*Survival 1967 (%)*	*Site*
37	2/0	87	Selwyn soils
64	2/0	95	Balmoral soils
62	2/0	98	Eyre soils

The trial area in compartment 64 covered 113 acres and was windrowed prior to ripping. The others covered only one acre each and were not windrowed.

COMPARISON OF RESULTS

Survival and Growth

As an initial improvement, ripping loosened the soils sufficiently to allow the use of planting spades and older (1½/0 and 2/0) tree stocks. This change in practice, and other obvious factors, invalidate any direct comparisons between crops established in ripped areas and those established prior to the introduction of ripping. The impressive survivals obtained in the trial areas (Table 3) led to the complete acceptance of the technique, and the absence of any designed experiment has not made it easy to find comparable data. However, sufficient small areas accidentally left unripped were located and accepted for comparison with adjacent ripped areas provided they were

(1) Planted simultaneously, with one seed lot, and using the same planting method.

(2) Not blanked.

(3) Not differentially affected by shade, excess run-off from roads, shelter from windrows or rabbit damage.

Five groups of 10 or 20 live trees were randomly selected from each treatment for objective comparison of survivals and height growths using the t test. These comparisons, shown in Tables 4 and 5, were made from measurements taken in March and May, 1970.

TABLE 4: COMPARISON OF SURVIVALS

Compt.	*Year Est.*	*Age of Stock*	*Treatment*	*No. of Samples*	*Mean Survival (%)*	*Difference*
32	1968	1½/0	Ripped	105 in 5 groups	95.5	Signif. at 1% level
			Unripped	198 in 5 groups	57.1	
54	1967	1/0	Ripped	127 in 5 groups	78.7	Signif. at 1% level
			Unripped	206 in 5 groups	48.5	
65	1967	2/0	Ripped	63 in 5 groups	79.4	Signif. at 1% level
			Unripped	138 in 5 groups	36.3	

Table 4 shows that ripping has had a significant effect in improving survival. In most cases over the last four years, survivals have been above the minimum required to eliminate costly blanking operations. Success was maintained in 1969 in spite of the exceptionally dry conditions experienced —

TABLE 5: COMPARISON OF HEIGHT GROWTHS

Compt.	Year Est.	Age of Stock	Treatment	No. of Samples	Mean Height (in.)	Coef. of Var. (%)	Difference
32	1968	1½/0	Ripped	5 groups of 20	18.0	3.9	Not. signif.
			Unripped	5 groups of 20	18.7	17.1	
53	1967	1½/0	Ripped	5 groups of 10	52.8	5.7	Not. signif.
			Unripped	5 groups of 10	52.2	17.4	
54	1967	1/0	Ripped	5 groups of 20	35.4	6.0	Signif. at 5% level
			Unripped	5 groups of 20	28.8	9.3	
65	1967	2/0	Ripped	5 groups of 10	40.4	9.6	Signif. at 5% level
			Unripped	5 groups of 10	35.6	6.0	

only 15.94 in. of rain fell during the calendar year compared with the annual average of 27.1 in.

As can be seen in Table 5, the response of height growth to ripping was not so reliable. There is no doubt that ripping has significantly improved height growth in some cases and, as shown by the coefficients of variation, has reduced the height variability in all except one case. Bear in mind that any height variation caused by the presence of natural regeneration, blanking and rabbit damage has been eliminated by careful choice of sampling area. Crop uniformity must be held as a great advantage for subsequent tending operations. The marked difference between crops established on ripped and unripped ground is clearly shown in Figs. 1 and 2.

Wind Stability

Earlier, mention was made of the restricted rooting capacity in unripped soils and Wendelken (1966) gives ample evidence of this under similar conditions in Eyrewell Forest. The effect of ripping, deep ripping (to 3 to 4 ft) and the direction of ripping on root habit and subsequent crop stability is to be studied by the Forest Research Institute — possibly employing tracer-isotopes. For the purpose of this paper, several trees planted in 1966 and 1967 were washed out of ripped lines in order to study early root development. The direction of the ripped lines whether at right-angles or parallel to the north-west, appeared to play only a small role in influencing root orientation. Each tree was anchored vertically by one strong root which seemed to take the place of the wrenched tap-root. A further root (or roots) was fairly strongly developed as a horizontal bracing root sent out downwind of the north-wester. Much finer tertiary roots — probably the main feeding roots — made up the bulk of the remaining

FIG. 1: *A stand of six-year-old radiata pine natural regeneration supplemented three and four years ago with 1/0 and 1½/0 stock planted on crushed lines.*

root material, and the biggest of these seemed to follow the ripped line. It cannot be foretold at this stage whether or not ripping is allowing the development of stronger bracing roots and hence a more stable crop. Indeed, recent toppling of trees 2 to 8 ft in height planted in ripped lines suggests that ripping could make the trees more susceptible to windthrow, at least at an early age. Root distribution on the toppled trees was excellent and it seems that the reason for toppling was directly attributable to the poor support offered by the loose, ripped soils. Ripping has not reduced the incidence of butt sweep in young trees and if toppling becomes a common occurrence, butt sweep could worsen considerably. Toppling aside, I feel that deep ripping could be far more beneficial to the stability of mature crops than shallow ripping which, after all, is no deeper than the current rooting depth in unripped soils.

Cost of Establishment

The cost of establishment on a windrowed and ripped site is compared with that on a crushed slash site, crushing being the most common site preparation technique immediately prior to the introduction of windrowing and ripping. Material costs incurred at the beginning of a rotation are shown in Table 6.

FIG. 2: *Radiata pine planted three years ago as 2/0 stock in lines ripped after windrowing.*

The survivals in the two compartments chosen for this comparison are quite representative — refer to Table 2 for survivals in two other compartments on crushed slash, and Table 3 for survivals in the ripping trial. No attempt has been made to carry these through to the end of a rotation because it is not known how long the ripped crop will benefit from faster initial growth rates, and subsequent tending costs of ripped crops are unknown. It can be assumed, however, that the initial cost advantage in the ripped areas will improve — tending costs will be reduced owing to crop uniformity and the slash-free working conditions. Other cost advantages of windrowed and ripped areas include such intangibles as easy access in case of fire, and possible windfirmness of the final crop.

DISADVANTAGES

(1) Removal of top soil by windrowing. Mention was made of this disadvantage by Chavasse (1969). From our experience, it appears that little topsoil is removed from the planting site. The reason for this could be that the stony nature of the soil allows the fines to sift out as the debris is being pushed.

TABLE 6: COMPARISON OF COSTS

Item of Expenditure	*Method of Preparation* — *Crushing* — *Details of Work Compt. 15 Planted 1965*	*Cost per Acre* $	*Windrowing and Ripping* — *Details of Work Compt. 53 Planted 1967*	*Cost per Acre* $
1. Site preparation	Tractor hire (D7) for crushing	5.50	Tractor contract (D9) for windrowing .... ripping	13.50 4.75
2. Planting stock	727 radiata pine 1/0 stock required to supplement natural regeneration to achieve 8 ft × 6 ft spacing	8.72	870 radiata pine 2/0 stock required to stock 95% of an acre at 8 ft × 6 ft spacing; 5% being lost in windrow	17.40
3. Labour	Bonus target of 59 trees per man-hour. Hourly rate of $1.25 for achieved target	15.00	Bonus target of 156 trees per man-hour. Hourly rate of $1.25 for achieved target	7.00
4. Blanking stock	29% survival. 477 trees of 1½/0 stock required	7.63	85.9% survival. No blanking required.	
5. Labour	Bonus target of 45 trees per man-hour. Hourly rate of $1.25 for achieved target	13.25		
6. Re-blanking	67% survival. Deemed satisfactory.			
		$50.10		$42.65 ($39.77 if 1½/0 stock is used)

(2) Loss of slash mulch. It is conceded that the removal of slash from the planting site results in some loss of mulch.

(3) Restricted access through windrows. The remedy is to plan to leave access gaps at strategic places — it costs no extra to have the contractor leave these clear.

(4) Loss of plantable area due to windrows. Measurements have shown that a 27 ft strip is left unripped in every 3 chains. Lost ground can be reduced to 15 ft by spot planting up to 6 ft within the windrows. Consequently, only one row of trees is lost in each windrow. This represents an insignificant loss considering the final crop will be at a greater spacing anyway.

(5) Better shelter for rabbits. There has been a notable increase in the rabbit population in recent years and it is thought that the windrows and rips could be providing more shelter. Damage to young crops is increasing.

(6) Greater surface wind speeds due to uniformity of canopy. The reduced variability in height growth within stands may increase the risk of stand collapse. It is hoped that a step-profile system of management (Wendelken, 1966) may help deflect and disperse potentially dangerous winds. Wind-tunnel studies at Canterbury University are under way to test the effectiveness of this system.

None of these criticisms are sufficient cause to revert to the old methods of establishment but efforts to improve the technique are being continued. A brief appraisal of some of the features under consideration follows. The gains from burning windrows do not compensate for the dangers involved — windrow fires in Eyrewell Forest have flared up in high winds as long as four months after the heaps were first lit, endangering nearby crops. Broadcast burning of slash prior to windrowing would be a safe way of achieving the purpose of reducing the ultimate size of the windrows and a bonus would be the return of ash nutrients to the planting site rather than having them concentrated along the burnt windrows. Mention has already been made of current research into the most efficient depth and orientation of ripped lines. There is considerable scope for improvement in establishment technique following ripping and it is hoped that current trials will add to the efficiency and versatility of this method of site preparation.

REFERENCES

Chavasse, C. G. R., 1969. Land preparation for forestry in New Zealand. *For. Res. Inst. Symp. No. 11.*

Prior, K. W., 1963. Planting trials at Balmoral Forest. *N.Z. Jl For., 8* (5): 820-3.

Wendelken, W. J., 1966. Eyrewell Forest: a search for stable management. *N.Z. Jl For., 11* (1): 43-65.

Wilson, H. H., 1969. Land preparation ripping. *In* Land preparation for forestry in New Zealand. *For. Res. Inst. Symp. No. 11.*